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Indian Standard

RECOMMENDATION ON UNITS FOR FLUID POWER SYSTEM

Fluid Power Systems and Components Sectional Committee, EDC 73; Terminology, Classification and Symbols Subcommittee, EDC 73 : 1 [Ref : Doc : EDC 73 (3826)]

1. Scope — This standard lists down the most commonly used units for fluid power system together with their symbols and dimensions.

2. Introduction

2.1 This recommendation defines the most usual 'Quantities' in the fluid power field and the 'Units' related to these quantities. The indications are in accordance with IS : 10005-1985 'SI units and recommendations for the use of their multiples and certain other units (*first revision*)'.

2.2 Additional quantities and units have, however, been added to cover all the scope of hydraulic and pneumatic transmissions.

2.3 In calculations, it is recommended that only SI units be used and not their multiples and sub-multiples thereby achieving consistency of terms and avoiding the need for correction factors.

2.4 Practical units are classified into three groups for each quantity:

a) Practical units as used in hydraulics,

b) Practical units as used in pneumatics, and

c) Practical units as used in fluid logic and fluidics.

3. Aim

3.1 The use of the symbol of quantities and practical units as shown in Table 1 is recommended to facilitate the understanding of catalogues, teaching or research manuals, and technical or commercial literature in general. It is also intended for the presentation of calculations and for the plotting of graphs.

3.2 The listed symbols for quantities and units and the names of units given in the table shall be used in calculation and for values in catalogues and business proposals. The table enables data to be transposed, and calculations to be simplified. This standard encourages the change from technical units still in use to International Units. International Units have been adopted by the majority of countries and their use should become general as soon as possible.

3.3 So long as the use of International Units does not become universal, the technical units may be used by engineers in the context of international exchanges.

4. Terminology — For definitions of terms relating to fluid power, reference shall be made to IS : 10416-1982 'Glossary of terms relating to fluid power system' and for the basic units mentioned in this standard, reference may be made to IS : 1890 (Parts 1 to 4)-1982 'Quantities, units and symbols: Part 1 Space and time, Part 2 Periodic and related phenomena, Part 3 Mechanics, Part 4 Heat' and IS : 10005-1985.

5. Application — As it is coherent, the Internal Units System does not give rise to any difficulties so far as calculations are concerned. If while calculating, it is convenient to leave technical units, these should be transposed in accordance with the formulae and the calculations shall be completed in International Units. If need be, the results may then be expressed in Technical Units also. (*Also see* Example).

Adopted 7 November 1988 © November 1989, BIS Gr 3

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Example:

Suppose the output of a pump be 'Q' (l/min) and the pressure 'p' (kgf/cm²). The power 'P' transmitted by the oil shall be expressed in International Units as follows:

	Data	*Expressed in base units*
Output of pump	$= Q$ (l/min)	$= Q \times \left(\frac{1}{60 \times 1\,000}\right) \frac{\text{m}^3}{\text{s}}$
Pressure	$= p$ kgf/cm²	$= p \times (9{\cdot}81 \times 10^4)\, \frac{\text{N}}{\text{m}^2}$

Required *Power Transmitted P*

Calculation

Power = output × pressure

$$P = Q \times \frac{1}{60 \times 1\,000}\left[\frac{\text{m}^3}{\text{s}}\right] \times p \times (9{\cdot}81 \times 10^4)\left[\frac{\text{N}}{\text{m}^2}\right]$$

$$= 1{\cdot}64 \times Q \times p\left[\frac{\text{m}^3}{\text{s}} \times \frac{\text{N}}{\text{m}^2}\right]$$

$$= 1{\cdot}64\, Qp \left[\frac{\text{Nm}}{\text{s}}\right]$$

$$= 1{\cdot}64\, Qp \text{ Watts}$$

To find the power in horse power, it may be convenient to write:

$$P \text{ (in HP)} = \frac{1{\cdot}64\, Q\, p}{736} \approx 0{\cdot}002\,23\, Qp.$$

EXPLANATORY NOTE

In this standard, various units for use in fluid power systems, in line with International Systems of Units, have been given for application fluid power systems and components industry, in order to bring uniformity.

In the preparation of this standard, considerable assistance has been derived from CETOP RP 71-1975 'Quantities, symbols and units of the International System (SI) to be used for fluid power', issued by the European Oil Hydraulic and Pneumatic Committee (CETOP).

TABLE 1 EXAMPLES OF SYMBOLS OF QUANTITIES AND PRACTICAL UNITS USED IN FLUID POWER SYSTEMS

(*Clause* 3.1)

Sl No.	Quantity				SI Units		Expression in Terms of SI Base Units	Units Commonly Used in Fluid Power Engineering	Commonly Used Practical Units for Fluid Power Engineering		
	Name	Symbol	Equation	Dimension	Name	Symbol			Hydraulic	Pneumatic	Fluid Logic and Fluidic
1	Length	l	—	L	metre	m	m	mm	mm	mm	mm
2	Area	A	—	L^2	square metre	m^2	m^2	mm^2	cm^2, mm^2	cm^2, mm^2	mm^2
3	Volume	V	—	L^3	cubic metre	m^3	m^3	l*, dm^3, cm^3	l*, dm^3	dm^3, cm^3	cm^3, mm^3
4	Shear strain	γ	$\frac{\Delta x}{d}$	1	—	—	—	—	—	—	—
5	Mass	m	—	M	kilogram	kg	kg	kg, g, Tonne(t)	Tonne(t), kg	kg, g	g
6	Specific volume	v	V/m	L^3M^{-1}	cubic metre per kilogram	m^3/kg	m^3/kg	dm^3/kg cm^3/kg, mm^3/kg	dm^3/kg	cm^3/kg	mm^3/kg
7	Density (Mass density)	ρ	m/V	ML^{-3}	kilogram per cubic metre	kg/m^3	kg/m^3	kg/l kg/dm^3	kg/l, kg/dm^3	kg/m^3	kg/m^3, g/m^3
8	Time	t	—	T	second	s	s	s	s, min	s	s
9	Time interval	Z	—	T	second	s	s	s	s	s	s
10	Time constant	τ	$\frac{1}{\delta}$	T	second	s	s	s	s	s	s
11	Frequency	f	$1/\tau$	T^{-1}	hertz	Hz	s^{-1}	Hz	Hz	Hz	Hz
12	Velocity	u, v	dl/dt	LT^{-1}	metre per second	m/s	m/s, m/min	m/s, m/min	m/s	m/s, m/min	m/s, m/min

*One litre = one dm³.

(*Continued*)

TABLE 1 EXAMPLES OF SYMBOLS OF QUANTITIES AND PRACTICAL UNITS USED IN FLUID POWER SYSTEMS — *Contd*

SI No.	Quantity				SI Units		Expression in Terms of SI Base Units	Units Commonly Used in Fluid Power Engineering	Commonly Used Practical Units for Fluid Power Engineering		
	Name	Symbol	Equation	Dimension	Name	Symbol			Hydraulic	Pneumatic	Fluid Logic and Fluidic
13	Volume flow rate	q_V	$\frac{dV}{dt}$	L^3T^{-1}	cubic metre per second	m^3/s	m^3/s	l/s, l/m dm^3/s, cm^3/s	l/s l/min, dm^3/min	l/min, dm^3/s (at NTP)	cm^3/s (at NTP)
14	Mass flow rate (mass flow)	q_m	$\frac{dm}{dt}$	MT^{-1}	kilogram per second	kg/s	kg/s	kg/s g/s	kg/s	g/s	g/s
15	Force	F	$m. a$	MLT^{-2}	newton	N	$kg. m/s^2$	N	N	N	N
16	Work	W	$F. l$	ML^2T^{-2}	joule	J, N.m	$kg. m^2/s^2$	J	J	J	J
17	Surface tension	σ	—	MT^{-2}	newton per metre	N/m	kg/s^2	N/m	N/m	N/m	N/m
18	Pressure*	p	F/A	$ML^{-1}T^{-2}$	pascal	Pa	N/m^2, $kg/(m.s^2)$	bar, mbar	bar	bar	mbar
19	Normal Stress	σ	F/A	$ML^{-1}T^{-2}$	pascal	Pa	N/m^2, $kg/(m. s^2)$	MPa, N/mm^2	N/m^2, N/mm^2	N/mm^2	N/mm^2
	Shear Stress	τ									
20	Bulk modulus	K	$-V.\delta p/\delta V$	$ML^{-1}T^{-2}$	pascal	Pa	N/m^2, $kg/m. s^2$	N/m^2, N/mm^2	N/m^2, N/mm^2	N/mm^2	N/mm^2
21	Power	P	dW/dt	ML^2T^{-3}	watt	w	J/s, $kg. m^2/s^3$	W, kW	kW	kW	kW
22	Dynamic viscosity	η, μ	$\frac{\tau}{dv/dY}$	$ML^{-1}T^{-1}$	pascal second	Pa. s	kg/(m.s)	Pa.s	cP†	—	cP†
23	Kinematic viscosity	ν	$\frac{\eta}{\rho}$	L^2T^{-1}	square metre per second	m^2/s	m^2/s	St (Stokes)	cSt‡, mm^2/s	—	cSt‡

24	Capacitance fluid	C_m	—	LT^2	kilogram per pascal	kg/Pa	m.s^2	kg/bar g/mbar	kg/bar	kg/bar	g/mbar
25	Conductance fluid	G_v	—	$M^{-1}L^4T$	cubic metre per pascal second	m^3/(Pa.s)	$\frac{m^4 s}{kg}$	bar. s^2/kg, mbar. s^2/g	$\frac{dm^3}{(bar. s)}$	dm^3 (bar. s)	$\frac{cm^3}{(mbar. s)}$
26	Resistnace fluid	R_m	—	$L^{-1}T^{-1}$	pascal second per kilogram	Pa. s/kg	$\frac{l}{m.s}$	bar. s/kg, mbar. s/g	bar. s/kg	bar. s/kg	mbar. s/g
27	Inductance fluid	L_m	—	L^{-1}	pascal second square per kilogram	Pa. s^2/kg	$\frac{l}{m}$	bar. s^2/kg, mbar. s^2/g	bar. s^2/kg	bar. s^2/kg	mbar. s^2/g
28	Thermo-dynamic temperature (absolute)	T	—	θ	kelvin	K	K	K	K	K	K
29	Celsius temperature	θ	—	θ	degree celsius	°C	—	°C	°C	°C	°C
30	Temperature interval	T	—	θ	kelvin	K	K	K or °C	K or °C	K or °C	K or °C
31	Quantity of heat	Q	$dQ = m.c.d\theta$	ML^2T^{-2}	joule	kg. m^2/s^2	—	kJ J	kJ	kJ	kJ
32	Heat flow rate	W	dQ/dt	ML^2T^{-3}	joule per second	J/s	$\frac{kg. m^2}{s^3}$	W, kw	kW	kW	kW
33	Specific heat capacity	c	$dQ/d\theta$	$L^2T^2\theta^{-1}$	joule per kilogram per kelvin	J/(kg. K)	m^2/s^2K	J/(kg. k), J/(g. K)	J(kg.K)	J/(kg.K)	J/(g.k)
34	Coefficient of heat transfer	h, k	$\frac{dQ}{dA, d\theta, dt}$	$MT^{-3}\theta^{-1}$	watts per metre square per kelvin	W/(m^2.K), kg/(s. K)	—	W/(m^2.K)	W/mm^2.K	W/mm^2.K	W/mm^2.K

*Gauge pressure unless otherwise stated (1 bar = 10^5 Pa).

†1cP = 1 mPa S.

‡1 cSt = 1 mm^2/s.

(*Continued*)

TABLE 1 EXAMPLES OF SYMBOLS OF QUANTITIES AND PRACTICAL UNITS USED IN FLUID POWER SYSTEMS — *Contd*

Sl No.	Quantity				SI Units		Expression in Terms of SI Base Units	Unit Commonly Used in Fluid Power Engineering	Commonly Used Practical Units for Fluid Power Engineering		
	Name	Symbol	Equation	Dimension	Name	Symbol			Hydraulic	Pneumatic	Fluid Logic and Fluidic
35	Angular velocity	ω	$\mathrm{d}\alpha/\mathrm{d}t$	T^{-1}	radian per second	rad/s	rad/s	rad/s	rad/s	rad/s	rad/s
36	Rotational frequency	η	$\omega/2\pi$	T^{-1}	reciprocal second	s^{-1}	s^{-1}	r/s r/min	r/min	r/min	r/s
37	Angular acceleration	α	$\mathrm{d}\omega/\mathrm{d}t$	T^{-2}	radian per square second	rad/s^2	rad/s^2	rad/s^2	rad/s^2	rad/s^2	rad/s^2
38	Torque	τ	$I.\alpha$	ML^2T^{-2}	newton metre	N.m	kg. m^2/s^2	N.m	N.m	N.m	mN. m
39	Volumetric displacement	V	L	L^3	cubic metre	m^3	m^3	m^3	l, cm^3	dm^3, cm^3	mm^3
40	Coefficient of volumetric expansion	α_V	$\frac{1}{V} \cdot \frac{\mathrm{d}V}{\mathrm{d}T}$	θ^{-1}	per kelvin or per celsius	K^{-1}	K^{-1}	K^{-1}	1/°C	1/°C	1/°C

Printed at Printrade, New Delhi, India